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ABSTRACT

Iron-deficiency anemia is almost certainly the most prevalent nutritional disorder among infants and young children in the United States. Anemia is frequently seen among children of low socioeconomic status but is probably also the most frequent nutritional deficiency disease seen among children cared for by private doctors. Possible reasons for the widespread occurrence of this disease are: (1) an erroneous belief among many physicians that iron is not absorbed before 2 or 3 months of age and that therefore it is useless to give iron to young infants, (2) lack of awareness among professional workers and parents that most unfortified foods provide limited amounts of iron, (3) inability of many parents to carry out a program of daily administration of medicinal iron, and (4) feeding of milk, a poor iron source, to infants in large quantities to the exclusion of iron-rich foods. Recommendations are given for average daily intake of iron. A massive educational effort directed to professional workers and to parents is urged, and suggestions are made for evaluation of maternal and child programs. Tables give data on the prevalence of iron-deficiency anemia and the iron content of commercial infant foods. (NH)

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PREVENTION OF IRON-DEFICIENCY ANEMIA IN INFANTS AND CHILDREN OF PRESCHOOL AGE

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IRON-DEFICIENCY ANEMIA is almost certainly the most prevalent nutritional disorder among infants and children in the United States. Etiology is known, prevention is feasible, and the group primarily affected can be readily identified as those between 6 and 24 months of age. The question is not whether iron-deficiency anemia can be prevented but rather which approaches to prevention are most practical. The importance of a fully adequate diet is self-evident; that this booklet empha-

sizes iron nutritional status should not obscure the importance of striving for adequate intakes of all essential nutrients.

Definition of anemia

For purposes of this booklet, anemia is arbitrarily defined as a state in which the concentration of hemoglobin is less than 10.0 gm./100 ml. of blood or the hematocrit is less than 31. The arbitrary nature of this definition should be stressed and it may be noted that various other concentrations of hemoglobin have been proposed. Thus, the Committee on Nutrition of the American Academy of Pediatrics states that "hemoglobin levels as low as 11 gm./100 ml., and hematocrits as low as 33% . . . should be considered 'normal'." Similarly, a WHO Scientific Group on Nutritional Anemias (1968) has recommended that hemoglobin concentrations less than 11.0 gm./100 ml. be used to define anemia in children from age 6 months to 6 years (but greater concentrations for older individuals). A value of 10.0 gm./100 ml. has been chosen as a reference point for this publication because more reports in the literature provide data on frequency of hemoglobin concentrations below 10.0 gm./100 ml. than below any other arbitrarily assigned value.

If anemia is hypochromic and microcytic, it is reasonable to assume that it is caused by iron deficiency. However, development of morphologic changes in the erythrocytes appears to be a less

sensitive index than other available measurements, including plasma iron, iron-binding capacity and percent saturation of transferrin. Recommended methods for these determinations are given in the Appendix.

Prevalence of anemia

Anemia as defined above (concentration of hemoglobin less than 10.0 gm./100 ml.) is frequently encountered among infants and young children of low socioeconomic status. Although it is seen less frequently among infants of similar age cared for by private practitioners in many geographic areas, iron-deficiency anemia is probably the most frequent nutritional deficiency disease in these children also.

Two reviews (Fomon, 1967a; Filer, 1969) and several recent reports of surveys have provided evidence that iron-deficiency anemia is common in some localities in the United States and relatively uncommon in others. Table I summarizes the more important recent studies. The relation of prevalence to age is well demonstrated by data from projects providing Comprehensive Health Services for Children and Youth: anemia was found in 28.5% of 1- to 2-year-old children, in 9.2% of 2- to 3-year-old children and 2.8% of 3- to 6-year-old children (Systems Development Project, 1968). Among Negro children in Washington, D.C., Gutelius (1969) found anemia in 46% of 6- to 23-month-old children and in 12% of 2- to 5-year-old

children.

The great variability in prevalence of anemia in various parts of the United States is apparent from a comparison of data for infants from low income families in large metropolitan centers (Andelman and Sered, 1966; Systems Development Project, 1968; Gutelius, 1969) with data for infants and young children in rural areas of Iowa (Kripke and Sanders, 1970). The prevalence of anemia among 4- to 6-year-old children enrolled in Head Start programs in five cities was found by Pearson et al. (1967) to range from 0.6% in Houston to 7.7% in Augusta.

Possible reasons for widespread occurrence

An erroneous belief exists among many physicians and nutritionists that iron is not absorbed before 2 or 3 months of age and that therefore it is useless to give iron during the first months of life. In fact, iron is absorbed efficiently by young infants (Garby and Sjölin, 1959; Gorten et al., 1963) and subsequently (by 3 to 4 months of age) is utilized in formation of hemoglobin.

There is lack of awareness among professional workers as well as parents that most unfortified foods provide rather limited amounts of iron (Table II). For practical purposes, iron-fortified foods for infants are limited to certain commercially prepared formulas (Table II) and cereals (Table III). Infants in the United States are less commonly fed iron-fortified formulas or cereals after 6 months

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of age than before that age (Fomon, 1967b).

Experience in several parts of the country indicates that many parents are unlikely to carry out a program of daily administration of medicinal iron.

Milk, a poor source of iron (Table II), is rather frequently fed to infants in extremely large quantities to the exclusion of iron-fortified foods and other foods.

Approaches to the problem

Although certain infants can be identified as being at unusual risk with respect to development of iron deficiency, it is by no means possible to identify all such infants. Therefore, efforts at prevention require a two-fold approach: (1) special measures directed at infants who can be identified as likely to develop iron-deficiency anemia, and (2) measures directed at all other infants, for whom average daily intakes of iron from one month to 18 months of age should be no less than 6 mg.

Because it is unlikely that most infants will receive the recommended amounts of iron from natural foods (Table II), prevention of iron-deficiency anemia requires regular administration of medicinal iron or of iron-fortified foods.

Sources of iron

Milk and formula: Human milk and cow's milk are poor sources of iron (Table II). Infant

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formulas supplemented with iron (generally to the extent of 8 to 12 mg. per quart) will provide 6 mg. of iron in the amount consumed by 1- to 2-month-old infants (average intake about 700 ml.); older infants consuming greater quantities of formula will generally receive more than 6 mg. of iron from this source.

Strained and junior foods: Commercially prepared strained and junior foods for infants are combinations of the specified food with water and frequently with additional carbohydrate (starch and/or sucrose). Therefore, the concentration of iron in a strained or junior food will usually be less per unit of weight than would be true for the corresponding food not prepared for infants. For example, the U.S. Department of Agriculture Handbook #8 (1963) lists beef chuck, choice grade, cooked, braised or pot-roasted (81% lean, 19% fat) as containing 49.4% water and 3.3 mg of iron per 100 gm. The section on baby foods of this Handbook lists strained beef as containing 80% water and 2.0 mg. of iron per 100 gm. The figures for the iron content of various strained and junior foods in Table II represent a summary of data from booklets supplied by the manufacturers.

Cereal: Since most dry infant cereals provide 50 to 70 mg. of elemental iron per 100 gm. (14 to 20 mg. per ounce of dry cereal), slightly less than one-half ounce of dry cereal (5-6 tablespoons) or three ounces of a cereal-milk mixture as it is usually fed, will provide 7 to 10 mg. of iron (Table

III). It is important to note that commercially available wet-packed strained cereal-fruit combinations are either unfortified with iron or fortified to a lesser extent than are the dry cereals (Table III).

Most cereals that require cooking (e.g., farina, oatmeal, rice, grits) are not fortified with iron or are fortified at extremely low levels. However, "Quick" and "Instant" Cream of Wheat are fortified with iron to nearly the same extent as are the dry infant cereals. One-half ounce of dry "Quick" or "Instant" Cream of Wheat (1 tbsp.) or 3⅓ oz. (6-8 tbsp.) of the cooked cereal provides 6 mg. of iron.

Although a 1- to 2-month-old infant is unlikely to consume sufficient cereal to provide 6 mg. of iron daily, by about 4 months of age he will readily consume such an amount. If the infant continues to receive cereal daily, iron from this source plus the small amounts present in many other foods will assure an average daily intake of 6 mg. through the first 18 months of life.

Medicinal Iron: For infants who do not receive iron-fortified foods beginning at 4 to 6 weeks of age, medicinal iron, preferably ferrous sulfate, is recommended in dosage to provide at least 6 mg. of elemental iron daily.

Recommendations

The intake of iron recommended here (average of 6 mg. daily from age 1 to 18 months) is somewhat less than that proposed by the Food and Nu-

trition Board (1968) or the Committee on Nutrition of the American Academy of Pediatrics (1969). The Food and Nutrition Board has recommended 6 mg. of elemental iron daily during the first 2 months of life, 10 mg. daily from age 2 to 6 months and 15 mg. daily from 6 months to 3 years. The Committee on Nutrition has stated that 1 mg./kg./day to a maximum of 15 mg. "if begun at an appropriate time with respect to initial iron endowment, will provide sufficient iron to maintain normal hemoglobin values in most infants." If hemoglobin concentrations of infants are to be maintained at or above 11.0 gm/100 ml. (the goal of the Committee on Nutrition), larger intakes of iron will be necessary than if concentrations are to be maintained at or above 10.0 gm./100 ml. as suggested here.

Much depends on the age at which dietary supplementation with iron is begun and how regularly this supplementation is provided. Thus, an average intake of 6 mg. of iron daily from age one month will provide a total intake of approximately 2,000 mg. of iron by age 12 months. If the diet has not been supplemented with iron during the first four months of life, approximately 8 mg. of iron daily between 4 and 12 months would be required to achieve the same (2,000 mg.) total intake.

With these considerations in mind, the following specific recommendations are offered:

1. A massive educational effort should be undertaken to reach all levels of professional and ancillary workers who counsel parents and,

through use of mass media, to reach parents themselves.

2. Recommendations regarding diet of infants and preschool children should include consideration of need for iron.

3. Vigorous efforts should be made to urge parents to feed iron-fortified foods to infants and toddlers.

Infants identified as likely to develop iron-deficiency anemia: Infants of low birth weight (less than 2.5 kg.), those of multiple births (twins, triplets, etc.) and possibly those born to mothers with several recent pregnancies, are prone to develop iron-deficiency anemia and will require more intensive preventive measures than will be needed for the remainder of the infant population. In addition, anemia among infants and toddlers is known to be endemic in certain localities, perhaps reflecting low body stores of iron of the women of childbearing age.[1] Infants in these groups should receive 10 to 15 mg. of elemental iron daily, the level of intake being adjusted on the basis of determinations of hemoglobin and/or hematocrit every 2 or 3 months. Use of medicinal iron will often be necessary to achieve the required intakes.

All other infants: Iron-fortified foods (i.e., iron-fortified formula or cereal) or medicinal iron should be introduced into the diets of all infants by 4 to 6

[1] The importance of maternal iron deficiency in the production of iron-deficiency anemia in the infant remains a matter of controversy (Oski and Naiman, 1966).

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weeks of age and continued until at least 18 months of age. If this recommendation is followed, average daily intakes of 6 mg. of elemental iron daily should be adequate to maintain concentrations of hemoglobin at or above 10.0 gm./100 ml.

Application to maternal and child health programs

The major effort in the prevention of iron-deficiency anemia in infants and young children should be an intensive educational campaign which includes both professional workers and parents. The need of the infant and child of preschool age for iron should be stated repeatedly and in different ways. The role of iron-fortified formulas and iron-fortified cereals in the prevention of iron-deficiency anemia needs to be emphasized.

In the case of infants of needy families, who are at special risk of developing iron-deficiency anemia, the provision or distribution of iron-fortified formulas, iron-fortified cereals or medicinal iron should be considered.

For adequate evaluation of a program, baseline data about the prevalence of iron-deficiency anemia should be collected even before educational or other activities are initiated. Data on concentrations of hemoglobin of infants and small children should be collected through well-child clinics, pediatric clinics, crippled children clinics, children and youth projects, maternity and infant care projects, clinical mental retardation programs and other spe-

cial projects. In addition, incidence of anemia among infants and children admitted to hospitals in various geographic areas should be determined. After instituting the proposed program of prevention, subsequent determinations of hemoglobin concentration will permit assessment of its effectiveness.

Information about infant feeding practices among low-income families with high incidence of iron-deficiency anemia should be collected.

Table I PREVALENCE OF

Location	*Age (yr.)*	*Number of Children*	*Percent Anemic **
Chicago	< 2	446	(76)
C&Y Projects **	1–2	1,813	28.5
Washington, D.C.	½–2	226	46
Iowa	½–3	583	4
C&Y Projects **	2–3	1,245	9.2
Brooklyn	< 5	1,359	25.5
Tennessee	< 6	15,681	—
Mississippi	1–5		
Low income		210	24
Higher income		342	12
Washington, D.C.	2–5	189	12
C&Y Projects	3–6	3,153	2.8
Head Start	4–6	7,000	
Houston			0.6
Jacksonville			1.7
Gainesville			2.8
Chicago			4.5
Augusta			7.7

* Concentration of hemoglobin less than 10.0 gm./100ml. or hematocrit less than 31.

** Comprehensive Care for Children and Youth Projects.

IRON-DEFICIENCY ANEMIA

Reference	*Comment*
Andelman & Sered, 1966	Repeated testing of same infant
Systems Development Project, 1968	
Gutelius, 1969	
Kripke & Sanders, 1970	Rural areas
Systems Development Project, 1968	
Hillman & Smith, 1968	
Hutcheson, 1968	Rural areas; 20.9% had hematocrits less than 32
Owen et al., 1969	
Gutelius, 1969	
Systems Development Project, 1968	
Pearson, 1967	

Table II

IRON CONTENT OF COMMERCIALLY PREPARED STRAINED AND JUNIOR FOODS FOR INFANTS *

	Elemental Iron (mg./100 gm. of food)
Meats	
Liver and a few others	4–6
Most meats	1–2
Egg Yolks	2–3
"Dinners"	
High meat	< 1
Vegetable-meat	< 1
Vegetables **	< 1
Fruits **	< 1
Milk	
Human	< 0.1
Cow's	< 0.1

* Iron content of commercially prepared strained and junior foods for infants is generally less than amount indicated in U.S.D.A. Handbook #8 (1963)—see text.

** A few varieties of vegetables and fruits provide 1–2 mg. of iron per 100 gm.

Table III

IRON CONTENT OF CEREALS

	Elemental Iron (mg.)
Iron-fortified infant cereals, dry, ½ oz.*	7–10
Wet packed, strained cereal-fruit combinations (100 gm.)	1– 6
Quick or Instant Cream of Wheat, dry, ½ oz.*	6
Other cereals, dry, ½ oz.*	0.5

* ½ oz. of dry cereal will provide approximately 100 gm. (3⅓ oz.) of cereal as fed (assuming that 1 part by weight of dry cereal is mixed with 6 parts of milk).

APPENDIX

Laboratory Methods

It is recommended that the concentration of hemoglobin be determined by the cyanmethemoglobin method (ICNND, 1963), and that the hematocrit (O'Brien et al., 1968) be determined. A mean corpuscular hemoglobin concentration of less than 31 gm./100 ml. of packed erythrocytes indicates hypochromia.

Determinations of iron concentration and iron-binding capacity in serum or plasma are also useful and can be done by micro methods. Plasma or serum iron and iron-binding capacity may be determined by the method of Fischer and Price (1964). Concentrations of iron in plasma or serum less than 60 μg./100 ml. suggest iron deficiency (Hillman and Henderson, 1969). Values above 360 μg./100 ml. are considered abnormal (Bainton and Finch, 1964) although the range of normal differs somewhat from one laboratory to another.

Percent saturation of transferrin is determined by dividing plasma iron by total iron-binding capacity and multiplying the result by 100. It has been suggested (Bainton and Finch, 1964; Smith, 1970) that percent saturation of transferrin less than 16 indicates that availability of iron has become a limiting factor in erythropoiesis. Further studies on this point are desirable.

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